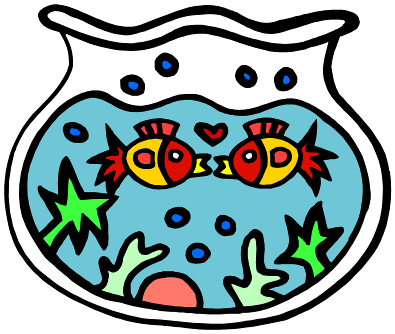
Aquariums in the Classroom



District of Columbia

Fisheries and Wildlife Division

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INTRODUCTION

An aquarium can be a beautiful and interesting addition to any classroom, and it is also a great way to teach students principles of aquatic science. In this seminar participants will be taught how to set up and maintain marine and freshwater aquariums in their classroom as well as how to incorporate it into a science curriculum. Additionally in the following pages we will discuss some of common problems encountered with aquariums, as well as how to recognize and treat common diseases in fish.

Above: Holacanthus ciliaris commonly known as the Queen Angel is a beautiful representative of marine fish.

We will begin our look at aquariums by examining the different types of aquariums: freshwater, saltwater and brackish. We will discuss the factors involved in deciding what type of aquarium is right for you. In chapters four and five we will discuss the different types of equipment that you will need to setup and maintain your aquarium, and how to actually set up the tank. In later chapters of the book we will discuss some of the common problems and diseases that can be encountered and how to correct and prevent such problems from occurring in the first place. Finally we will talk about how an aquarium can be used as a learning tool in the classroom and what types of resources exist for you, the educator, to best utilize the aquarium as a learning tool.

CHAPTER ONE

Prior to setting up an aquarium in your classroom the first thing that needs to be decided is what type of creature(s) you wish to keep. While many people set up an aquarium first, only later to decide what type of fish (or other organisms) they wish to keep, it is better to decide on the type of fish you wish to keep prior to setting up the aquarium. This way you can create the proper habitat before introducing the animals. Once you have decided what type of fish you want to keep it is a matter of designing an artificial habitat that will be appropriate for your target organism(s). One of the first things you need to consider is the type of water necessary to maintain this animal. Will the animal require a freshwater, saltwater or brackish water habitat? As a general rule of thumb marine or saltwater aquariums require the most attention and necessitate the best water quality. In this chapter we will discuss the freshwater aquariums and some of the factors that should be considered prior to setting up your freshwater aquarium.

By far the simplest aquarium to set up and maintain is the freshwater tank. Once you have decided that this is what you wish to do, then you must consider the types of aquatic life you want to keep. Assuming you have decided that there is a certain target organism you wish to keep, now is the time to consider other specific requirements of the animal(s). Lets first consider where the creature is found in nature. Does it come from a coldwater or tropical habitat?? Most fish you will find in the local aquarium store will be tropical in nature. What does it mean to be tropical?? Many incorrectly confuse tropical with marine. This is not the case. Tropical simply indicates that the fish comes from a tropical environment, one that is located between the tropic of Cancer and the tropic Capricorn. This would include a majority of the popular aquarium fish such as Angelfish, Tetras, Barbs, Gouramis and many others. These fish come from areas in South America, Africa, Asia and other regions that fall between the two tropics. The most important aspect of the tropical origin of these fish is temperature. In the tropics there is generally little dramatic temperature fluctuation. This means the fish are generally use to a very stable temperature and do not tolerate large temperature fluctuations well. Therefore, when we set up an aquarium for tropical fish we will want to consider the need for a stable temperature. On the other hand, there are also fish known as temperate fish. These are fish that come from areas that are outside the tropics. Fish from these habitats would be adapted to tolerate large temperature fluctuations. A temperate climate fish is from areas where dramatic seasonal temperature changes can be experienced, such as the District of Columbia. The most common temperate fish, sold in aquarium stores, is perhaps the

Angelfish in a nicely planted freshwater aquarium.

goldfish. These fish can tolerate a wide range of temperature and although they may benefit from a stable temperature it is not necessary to their survival.

The next major consideration to keeping a freshwater aquarium is water composition. To design a successful aquarium we should consider where the fish is found in nature. There is a big difference between the water in the Amazon River and that of the Rift lakes in Africa. Why does water quality vary in different parts of the world? To understand this we must consider the hydrological cycle. When water evaporates it is generally the pure water that evaporates. If we were to mix a cup of saltwater and allow it to evaporate over time we would find that the salt would remain even after the water had evaporated. This means that the pure water that evaporates is very soft, and therefore contains little or no dissolved minerals. Once condensation occurs and rain falls back to the earth it comes in contact with the soil and picks up minerals and elements found in the soil. In areas that have a great deal of limestone, for instance, the rainwater would acquire calcium, which can lead to alkaline water. On the other hand if rain falls to soil that contains granitic rock, the water composition is altered very little meaning that the water will remain soft. In a freshwater aquarium the most common way to test the overall character of the water is to test the pH. The pH is a scale, which is used to determine the acid or base concentration of water. The pH scale goes from 0, which is the acidic side of the scale, to 14, which is the alkaline or base. When we are looking at fish aquariums we are generally looking at much narrower range, which is from 6.0 to up to 8.5. Although, as a rule of thumb we aim for a pH of 7.0 (neutral) for most freshwater fish this is not true for all. If in nature a fish comes from an environment that has a naturally occurring pH of 6.6 to 7.4 it would likely still do well at a compromised pH of 7.0. While many freshwater fish will survive and thrive at this neutral pH some will not. You must consider the extreme environments. The African Cichlids are a good example of this; they come from lakes that are very alkaline in nature with a pH up to 8.0. Although these fish may survive at a pH of 7.0 it is not recommended. The fish will generally do much better in the proper environment. The discus fish of the Amazon River are another example of an extreme environment. These fish are from the backwaters regions of the Amazon, which has a high concentration of peat, which leads to very soft acidic water. Again these fish might survive for a period of time at a neutral pH, but this would not be recommended. The point here is that a fish will do best in an aquarium that is designed to mimic its natural environment as closely as possible. Therefore once you have decided on the fish you wish to keep find out what type of pH they would be accustomed to by nature and provide that environment.

Some fish have more specific pH requirements like this African Cichlid seen above.

Now that we have discussed water chemistry and temperature we know that not all freshwater fish could be in the same tank together due to different needs or requirements. Although it can be done, it is not a good idea to mix coldwater fish with tropical fish, since one will be compromised. It would also then not be appropriate to mix fish that came from drastically different water chemistry such as discus that require soft acidic water and African cichlids that are accustomed to hard alkaline water conditions. What other factors then might determine fish compatibility?

Other major factors that determine fish compatibility would be size and temperament. While there are many fish that are considered peaceful community fish others are deemed aggressive. A peaceful community fish is one that can co-exist happily with many other types of fish in an aquarium. However, notice I said "many other types of fish" not all but many. The point here is that NOT all community fish can go together in an aquarium. Although community fish are generally considered non-aggressive even a community fish may eat a smaller fish if it can. A basic rule of nature in the fish world is that "if I can easily get my mouth around you...I might eat you". This is not aggression, but rather survival, and the food chain at work. Therefore, we should avoid putting very very small fish with fish that have large enough mouths to swallow them. In other cases some community fish are not compatible for different reasons. One case might be the angelfish and the tiger barb, while both would be considered community fish they would not necessarily be good tank mates. Anyone that has ever seen an angelfish will recall its long, beautiful flowing fins. Well it turns out that tiger barbs are notorious fin nippers, and they would likely damage the angelfish's fins. Basically although tiger barbs are fine with many community fish they are not suitable in all community tanks.

Above: Commonly known as the Siamese Fighting Fish, the Betta splenders , will generally only exhibit aggression towards other males of it same species.

Some fish are considered to be aggressive and do not make appropriate tank mates for many peaceful community fish. An example would be a piranha, which is an aggressive carnivore that would likely eat other fish species in the tank. However several piranhas in the same aquarium will often do just fine. Often time aggressive fish are fine with other aggressive fish. An example of this would be a Jack Dempsey and an Oscar, both aggressive, but they will often co-exist due to comparable size and behavior. So as a loose rule aggressive fish would go with other aggressive fish. However, this does not mean that all aggressive fish can be kept together, as they may have different requirements in other areas (water chemistry, temperature, etc). If we were to look at an African Cichlid and a Jack Dempsey (from South America) they would have different water requirements as far as pH goes, thus they would not be appropriate tank mates. Also not all

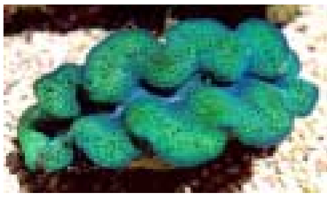
Above: A Red Oscar (Astronotus ocellatus), is certainly not a suitable tankmate for small "Bite Size" fish.

aggressive fish are aggressive in the same way. Some fish are aggressive feeders meaning that they are very aggressive when it comes to getting their lunch. While other fish are territorially aggressive. A fish that is territorially aggressive will often find a space in the aquarium that is his "turf" and he will aggressively deter other fish from entering his territory. Also size is again a factor, while two aggressive fish may co-exist together without complication if they are drastically different sizes it can cause a problem. Take the well know Betta (Siamese Fighting) fish, although these fish are conspecific aggressive (aggressive with members of the same species), they are often fine with other species. However if a Betta and a Jack Dempsey were put in the same tank, although they are both aggressive, the Jack Dempsey would likely eat the smaller Betta. As a review, the major factors in determining whether fish will make suitable tank mates are 1.) disposition (community or aggressive), 2.) water chemistry and 3.) size.

Therefore, before we begin to set-up our classroom aquarium, we should consider the importance of deciding what will go in our tank once it is set-up. This way we can ensure success by providing the proper water chemistry, temperature, and appropriate tank mates. This is of course essential as we have already discussed in a freshwater aquarium, but all of these issues are also important in marine and brackish aquariums.

CHAPTER TWO

Setting up a marine aquarium can provide all of the same challenges as we have already discussed that are relevant to freshwater aquariums, such as temperature, water chemistry and the compatibility of tank mates. However, in marine aquariums water chemistry becomes even more of a concern. Why is water quality so much more important in marine aquariums one might ask? Well simply put, saltwater fish are far less tolerant of improper conditions than their freshwater counterparts. Marine fish of course come from the oceans and seas, which are very large and relatively stable bodies of water. Consider this, a cup of water and a five gallon bucket of water sitting out on the sidewalk on a cold day, which will freeze first? Of course the cup, which is a smaller quantity of water will freeze first. Well, the basic premise here is that fluctuations occur much slower in larger volumes of water. This means that in nature an ocean would be a much more stable environment than a river. If an organism is from a very stable environment it is often not well equipped for fluctuations or changes to its habitat. Therefore, with a marine aquarium we must try to maintain a very stable environment. Basically there is much less margin of error in a marine tank as opposed to a freshwater tank, due to the much narrower range of tolerances innate to marine fish.



Above: A beautiful specimen of Tridacna crocea, a species of giant clam. This species is commonly kept in saltwater "Reef" aquariums.

Temperature is an important aspect in the marine aquarium as it is in the freshwater aquarium. Almost all marine fish that are commercially available are in fact tropical and again require a warm stable temperature. The target temperature is generally about 76° F but can range as high as 80° F. The important thing here is stability, you want to avoid any situation where temperature is likely to change rapidly as this is very stressful on marine fish.

As previously mentioned water quality is critical to marine aquariums. However, we are really concerned with many issues here not just the pH of the water, but also the proper alkalinity and salinity. Since oceans are fairly stable when it comes to pH we need to concentrate on a very specific pH range. The pH we generally aim for in a marine aquarium is 8.3, since most of the worlds' saltwater is fairly uniform in this regard. Closely related to pH is alkalinity of water, alkalinity is the measure of waters buffering capability. How resistant to change is the pH, this is alkalinity. The proper alkalinity means that the pH is much less likely to change. This is especially a concern in a marine aquarium, where alkalinity is much more likely to fluctuate than in natural marine habitats. Since marine fish have a narrow range of tolerance for pH it becomes important that we maintain the proper alkalinity to avoid pH fluctuation. There are many commercially available test kits to measure parameters such as alkalinity. We

Above: The Clownfish is a very popular marine fish, which is commonly captive bred now around the world.

will cover testing equipment later in greater detail. The final big element to consider with water quality is salinity. Salinity is the measure of salts in the water that make up seawater. Of course it goes without saying that if we want a saltwater aquarium we need to add salt. How do we get the proper mixture of salt and water? Well if you lived close enough to the ocean you could actually go to the ocean to collect water for your aquarium. However if you chose this method you should not collect your water right along the coast where pollutants are often more concentrated, but rather travel a short distance into the water by boat and collect the water offshore. This could prove to be a formidable task, therefore many people that do live near the ocean chose to use synthetic sea salts. Synthetic sea salts are now widely available commercially and quite good. These synthetic sea salts contain not only sodium chloride but also a host of other salts and trace elements just like natural seawater. These salts are easy to mix and will have your tank ready for fish in no time. However, even if you follow the directions on the bag of salt you will still want to verify your salinity before adding fish. In a marine aquarium we generally use a device called a hydrometer to measure salinity, actually a hydrometer really measures the density of the water, which gives us a basic idea of the salinity.

Above: The Yellow Tang (Zebrasoma flavescens) will eat many types of marine algae as well as romaine lettuce.

As we discussed previously with regards to freshwater aquariums, in marine aquariums it is important to choose your potential tank mates carefully. In the marine environment there are also many peaceful community fish that can coexist together in the same aquarium with no problem. There are however more species that display conspecific aggression, in the world of marine fishes. Therefore while one Yellow Tang maybe fine in a community tank two may fight. This is true of some species, but certainly not all. There are also aggressive carnivorous fish that are sometimes kept in marine aquariums, like the venomous Lionfish. As a rule of thumb aggressive fish should go with other aggressive fish of similar size and disposition. Size again can be an issue, as marine fish with a mouth big enough mouth to eat a smaller tank mate often will.

CHAPTER THREE

Although not as popular in the aquarium world, brackish water tanks can be quite interesting. Brackish water is water that contains some salt, but not as much as is found in saltwater. Basically it is water that falls between freshwater and saltwater in terms of salinity. Where would we find brackish water in nature? The most common examples are bays and estuaries. Estuaries are where freshwater and saltwater meet. The Chesapeake Bay is an excellent example of an estuary. In the Chesapeake Bay we have water from the rivers and stream mixing with the oceanic waters from the Atlantic. However, the amount of salt in the waters of an estuary varies greatly depending where in the estuary you look. If we were to look at the upper part of the Chesapeake Bay where the Susquehanna River empties into the bay the salinity would be much lower than if we looked at the mouth of the Bay where it meets the Atlantic Ocean. When setting up a brackish aquarium I suggest doing so like you would set up a freshwater aquarium if you were planning to make a brackish tank that mimics the lower salinity areas of an estuary. However if you wanted to set up a heavily brackish tank, one with a salinity that approaches that of saltwater I would set the aquarium up following the guidelines for a marine aquarium.

Above: One commonly kept brackish water fish is the Green Spotted Puffer (Tetraodon nigrifilis).

CHAPTER FOUR

The first piece of new equipment you will likely choose will be the actual aquarium itself. What size tank is right for you is dependent on several factors such as the size of the area were the aquarium will be placed, your budget and the type of fish you want to keep. Perhaps the best place to start when considering what size aquarium is ideal for you is to begin by again thinking about the type of fish or creatures you want to keep. You want to consider how big the biggest fish will possibly be at full maturity. This is a good place to discuss a common myth about fish size. It is a common belief, often perpetuated by the pet industry, that a fish will only grow as big as its environment allows. Many believe that tank size determines fish size. There is a thread of truth to this, but merely a thin one. Basically fish, just like human beings, have genetic code that dictates their growth. Do people that live in small apartments not grow to be as tall as those that live in big houses?? Of course not, nor is fish growth potential determined by aquarium size. Now for the thread of truth in this myth, if a fish is in a tank that is too small for it, its growth maybe be stunted and it may die prematurely due to poor water conditions. As a fish gets bigger and bigger it makes more and more waste, which can actually build up to toxic levels. This decrease in water quality will often lead to the premature death of the fish, and hence his growth is in fact limited by environmental conditions. Additionally, some fish actually release growth inhibiting hormones that reduce the growth of competitors, which can be more concentrated in a small closed system environment like an aquarium, leading at times to decreased growth potential. So as you can see, it is important to consider the potential size of any fish you wish to keep before purchasing a tank. It certainly would not be realistic to put an Oscar, which can reach up to 16 inches, into a 10-gallon aquarium that is only 20 inches long.

Shown above is a standard glass aquarium, a popular choice for most aquarium hobbyist.

The next factor to consider is water volume. The greater the water volume of the aquarium the more stable the system. In a larger aquarium it takes longer for waste to build up, for temperatures to change, or for oxygen to be depleted. One way to look at this is by looking at a phrase that was once very common in the environmental field. The phrase stated: "The Solution to Pollution is Dilution". The way this relates to an aquarium is that in a larger aquarium factors like fish waste would be more dilute if there is more water in the aquarium, where in a small tank the waste would be more concentrated. With this said, I would encourage anyone starting in the aquarium hobby to purchase the largest aquarium which would be feasible for their purpose. A larger tank is easier to maintain and is less prone to fish loss due to generally better water quality.

Another factor to consider related to aquarium size is surface to volume ratio. The open surface of the tank, where the water is exposed to the air is quite important. Although aquariums come in many shapes and sizes, perhaps the most common is the rectangular design. The benefit to this design when compared to more nontraditional designs, such as hexagonal or column type designs, is that the rectangular design has more of the water surface exposed to the air. Why is this important? Gas exchange is the answer. The exposed surface of the tank is where crucial gas exchange takes place. The surface facilitates the mixture of oxygen with the water and the release of gases such as nitrogen gas (N_2) and nitrous oxide (NO_2), which are byproducts of denitrafication. A tank that has a greater surface to volume ratio is capable of a greater bio-load (the number of living creatures) due to the oxygen required by living organisms. Therefore a 30-gallon rectangular aquarium that measured 36 inches by 12 inches would have a surface area of 432 square inches, when compared to a 30-gallon cylindrical aquarium with a 10-inch radius, which would have a surface area of 314 square inches. We can see the more traditional rectangular aquarium has a greater surface area, and would therefore be more efficient in the arena of gas exchange. This is not to say that a tall narrow tank is bad, but only to say that such a tank should be stocked less densely as the bio-load capacity is lower due to a lower gas exchange capacity.

Now that you have chosen a new aquarium you must find a suitable place to for it to reside. The best choice is an aquarium stand designed to hold an aquarium. These are available in a wide variety of colors and types. When you purchase a stand specifically designed for an aquarium you have the assurance that it is made to hold the tremendous weight of an aquarium. You need to consider the weight of an aquarium when deciding on an appropriate stand. Each gallon of water will contribute approximately 8.5 pounds of weight, so that even a small 10-gallon aquarium needs a stand to support over 85 pounds of weight. Although there are many pieces of furniture that can support the weight of a small aquarium, larger aquariums will be much heavier and I strongly suggest buying a stand designed for the particular aquarium you choose. Additionally, it is critical that the surface that you place your aquarium on is flat and level, as unlevel surfaces can result in stress fractures. Additionally most aquariums come with a warranty that is only valid if an appropriate stand designed for the aquarium is used.

Aquarium stands are available in many different styles for standard aquariums.

Often when you purchase an aquarium it comes with some form of illumination. This however is not always the case, and in some cases you should consider aspects like lighting prior to purchasing the aquarium. When and why is lighting an important consideration? The answer is, when you want to include light dependant organisms in your aquarium such as live plants or perhaps corals in the case of saltwater.

When you purchase an aquarium that includes a hood and light it will generally include a fluorescent lighting system. This system is generally adequate for lighting the aquarium to display your fish, but is not necessarily the right choice if you want to keep light dependant organisms. However in the case of a small tank, such as a 10-gallon you might have a choice between fluorescent and incandescent. If this choice is given I would generally suggest you chose the fluorescent system. Incandescent bulbs will not give you the bright evenly distributed light that a fluorescent will provide. Additionally incandescent bulbs can generate a substantial amount of heat that can lead to temperature fluctuations that can be stressful on fish.

Lets consider for a moment that you want live plants in your aquarium. Is the lighting system that comes with most tanks adequate for plants? That answer really depends on the types of plants you wish to keep. Some plants need a lot of light, while others need much less. A plant that has minimal light requirements might do just fine with the standard fluorescent lighting system that is included with many aquariums. Even though many plants will survive with this system, many will not. The bulb that is generally included with the standard aquarium lighting system is designed to illuminate the tank and is design more to be aesthetically pleasing to one viewing an aquarium, but offers little benefit to most plants. There are, however bulbs specifically designed to benefit plants. These bulbs produce a spectrum of light that is designed to mimic natural sunlight. These bulbs are readily available at most pet shops in many brand names such as Vitalight, Coralife, Triton and Growlux. This bulb will replace the bulb that came with your aquarium and should be replaced annually to ensure optimal performance. In some cases, however, even with a special bulb you still will find that some plants need more light. There are aquariums hoods that include lighting systems that feature two bulbs instead of just a single bulb. These dual-strip hoods, as they are often referred, can be a good choice for those that really want to keep plants that need better lighting. These hoods can even be ordered with your new aquarium in place of the standard single strip light hood. Of course it would be wise to replace the bulbs that are included with this lighting system with full spectrum or grow bulbs. In some cases with very large tanks or very deep tanks still more lighting is needed than even the dual strip hood will provide. In this case we would look into high intensity lighting systems. One such system is called VHO lighting, which stands for Very High Output. These bulbs will not fit into a standard aquarium hood, but require a special electronic ballast and custom hood. Basically these bulbs offer 2-3 times the brightness than a standard fluorescent bulb. If you think you may require this type of lighting it is best to get some advice from an aquarium professional, as even pet shops are often unfamiliar with these systems.

Special bulbs designed specifically for aquarium use are available for almost any application.

Now lets imagine you wanted to set up a coral reef tank. This application can require even more emphasis on lighting than even the most heavily planted aquarium. Many of the creatures that would reside in a reef aquarium like corals and anemones, for instance, have very specific lighting requirements. Not only is the quantity of light important, but also is the quality or type. Like previously mention with regards to live plants, there are a number of specialty bulbs used to light reef aquariums. One bulb that is commonly used is what is called an actinic bulb. This bulb produces a spectrum of light that is common to corals in their natural habitat and appears to be blue in coloration. Why might blue light be more common in a natural reef environment? As light penetrates water with increasing depth certain spectrums are filtered out. The blue coloration is one of the last colors filtered out as the light travels through the water. This means that corals would receive a greater percentage blue light in their natural habitat. Therefore in an aquarium, where we endeavor to recreate natural ecosystems, we would want to provide light that would mimic the natural ecosystem as closely as possible. In addition to using the actinic bulb, we will generally also use a full spectrum or daylight bulb, much like the bulb used for live plants. As a basic rule a good formula for lighting for reef aquariums is a one to one ratio of actinic and full spectrum lighting. Now that we have discussed the type or quality of lighting, lets look at the quantity requirement. Most of the light dependant reef organisms require a fairly high intensity. Although a simple dual strip hood equipped with the proper bulbs may suffice for some reef organisms in many cases more light is still required. Again we look at high intensity lighting systems. The three most common types of high intensity lighting systems are VHO fluorescent, compact fluorescent, and metal halide. These systems all have there own merits, choosing which is best for a particular application can get quite complex. The important thing to realize is these systems all exceed standard fluorescent lighting greatly with regards to output. To illustrate this point lets consider a 48-inch standard fluorescent bulb (also referred to as a NO bulb signifying Normal Output) and a 48-inch VHO fluorescent bulb. The standard fluorescent or NO bulb is a 40-watt bulb, while the VHO fluorescent bulb is 100-watt. Now is it necessary to mention wattage is a measure of input not output, that is to say how much power the bulb draws. However greater input will generally equate to greater output, unless there is an extreme difference in efficiency. This is certainly true in this case as a VHO bulb is typically two to three times brighter than a NO bulb with regards to output, which is measured in lumens. So how much lighting is necessary for the reef aquarium? There are a lot of factors to consider answering this question, but we can make some simple generalizations. A loose rule would be 3-4 watts of light per gallon of tank capacity. This would mean in a 55-gallon aquarium you might require 165 to 220 watts. In this case we could chose to use either 5 NO bulbs or just 2 VHO bulbs. The fact that with high intensity lighting you require fewer bulbs can lead to a long-term savings in money, as bulbs should be replaced annually. This formula while a good place to start is really an oversimplification as factors like tank depth and the specific type of coral you wish to keep are negated. However, this will help in order to obtain a quick and dirty estimate.

Perhaps the most critical piece of equipment you choose for your aquarium is the filter. A filter is what determines the water quality and should be considered a vital piece of life support equipment. A high quality filter is extremely important and should not be compromised. Before we discuss the specific factors of choosing a filter we should first look at the premise of filtration.

In aquarium filtration there are three primary aspects of filtration: biological, chemical, and mechanical filtration. All of these aspects of filtration are generally present in the modern power filter.

The first process in most filters is the mechanical filter, this is where large particles and debris are entrapped or removed in the filtering process. This maybe as simple as a strainer on the intake tube of a filter, that does not allow large debris to pass into the filter. Basically think of mechanical filtration as the step that prevents large chunks from entering the filter.

Filters are available in a wide variety of shapes and sizes. Shown above is a popular canister filter design.

Chemical filtration is a method of altering the chemical makeup of the water. In most cases after water passes through a mechanical filter it enters into some sort of chamber where chemical and biological filtration occur. Once in this chamber the water will often pass through or circulate around some sort of chemical media such as activated carbon or zeolite. The most common form of chemical filtration is activated carbon. Carbon removes many chemical impurities from the water and aides in the purification process. This is very much like systems that are used to filter water, which is used for human consumption. Another common chemical media in freshwater is zeolite, which is a media that absorbs ammonia released by the fish to prevent toxic ammonia blooms. There are other types of chemical media used in aquariums to remove specific substances like resin that absorbs phosphates or heavy metals, but generally activated carbon is the one most often used in filters for chemical filtration. Basically the primary function of chemical filtration is to purify the water.

The outside powerfilter is a very popular method for many aquariums

The final, but perhaps most important, aspect of filtration is biological filtration. To understand biological filtration we must first understand some key biological processes as they occur in the natural world. In nature when a fish eats it processes food and of course releases waste. The primary waste of the fish is ammonia (NH_4). Ammonia is extremely toxic and could pose a threat to the fish and other aquatic animals. Plants and algae for which the ammonia is a key nutrient assimilate some of this ammonia but much is not and remains in the water. Therefore a threat remains to the fish. However in nature there are microscopic bacteria (nitrosomas) that convert ammonia to a slightly less toxic substance known as nitrite (NO_2). This nitrite is still relatively toxic and could still pose a significant threat to fish and other aquatic wildlife. Fortunately another type of bacteria (nitrobacter) converts the nitrite to nitrate (NO_3), which is about two hundred times less toxic than the ammonia and only dangerous if in very high concentrations. This process is known as nitrification and is very important in nature as it is in aquariums. Basically this process causes waste products to be utilized by bacteria for energy leading to the detoxification of the waste. A further process called denitrification actually breaks the nitrate down to form nitrogen gas (N_2) and nitrous oxide (NO_2) that are released from the water into the atmosphere, which is 78% nitrogen. The complete process of nitrification and denitrification make up the nitrogen cycle. Now that we understand the way fish waste is broken down in nature we can apply these same theories to the aquarium system. A biological filter is one that provides tremendous surface area, which bacteria colonize so that they can break down the waste of the fish. A biological filter can take many shapes and forms. One simple form is a sponge. A sponge has a very high surface to volume ratio and is an ideal media for bacteria to colonize. In some filters specially designed bio-media is used that may resemble small plastic balls with many projections, again the idea is to maximize surface area for bacteria to colonize. In essence a biological filter is simply a media with high surface area that fosters the growth of populations of bacteria that naturally detoxify the fish waste.

Now that we have a basic idea of the steps involved in filtration let us examine some of the different types of filters. First we will look at hang on back power filters, external canister filters and internal canister filters. Perhaps the most popular form of filtration for small aquariums is the hang on back power filter. This filter incorporates all three types of filtration into a small easy to maintain package that uses disposable media cartridges or elements. These filters are quite good for small (under 100 gallons) freshwater aquariums. There are many popular brands such as Whisper, AquaClear, Marineland, and others. The main factor to consider when purchasing such a filter is the capacity, especially when it pertains to the biological media. It is a good idea to look for one that incorporates some sort of semi-permanent biological media such as a foam block or sponge rather than one in which a single disposable cartridge design. If the whole filter media is disposable you will sacrifice your biological component each time you replace the cartridge, this is why one that has a semi-permanent biological media is preferred. Another popular form of filter is the external canister filter. These filters offer a very large media chamber to hold a high capacity of chemical and biological media. Perhaps the biggest benefit of these systems is that they are relatively low maintenance. While a small hang-on back power filter may need monthly cleanings a large capacity canister filter can often go months before cleaning is needed. The external canister filter can be a great choice for medium to large (55-125 gallon) freshwater and marine aquariums. Closely related to the external canister is the internal canister filter. These are small filters that are completely submersible. While these filters are a great option when keeping a small aquarium that is only partially filled, such as might be the case if keeping small amphibians, they are not generally as powerful or efficient as external canister or hang on back power filters. Basically this is a filter that fills a specific niche being shallow water tanks.

Next lets take a look at some of the first filter technologies used in the aquarium hobby the undergravel filter and the corner bubble up filter. One of the first filters to gain popularity was the undergravel filter system. This system uses a slotted plastic plate that goes underneath the gravel to make the entire substrate into a biological filter. Connected to the plate on the bottom of the aquarium is some sort of hollow plastic tube, at the top of which sits a small container of activated carbon. Within the hollow tube is an airstone, connected to an airpump which produces bubbles. The basic idea is that the bubbles cause water to be pulled through the gravel bed and under the undergravel filter in essence circulating the water. Bacteria that colonize the gravel bed break down the waste of fish as the water is pulled through. An alternate method (and more efficient) of running an undergravel filter is to use a small water pump called a powerhead to actually pump water through the gravel. While one can certainly maintain an aquarium using an undergravel filter it would not be my recommendation. These filters have several problems such as poor circulation, little media, anaerobic potential and sludge build up. The undergravel filter system was certainly a vital part of the history of the aquarium hobby, but currently there are many better options on the market for filtration. Another filter whose day has come in my opinion is the corner bubble up filter. This is basically a small plastic box that holds chemical media, such as activated carbon and a biological media like filter floss. A small external airpump blows air into the filter causing water to circulate through the filter where it is exposed to the filter media. Bottom line these filters can work in lightly stocked aquariums, but are really not the most efficient filter, I would suggest avoiding these.

In recent years other filters have also worked there way onto the market such as the wet/dry filter and the sand filter. The wet/dry filter is basically a very efficient biological filter. A typical wet/dry filter is an acrylic container of some type that is filled with specially designed biological media such as bio-balls. Water is drained from the aquarium to the wet/dry filter, which usually sits below the tank, by gravity. The water enters the filter where it is sprayed or drips over the biological media, which is not submerged. As the water trickles over the media it is exposed to dense bacteria populations, which break down the nitrogen based fish waste. The idea here is that the bacteria involved in biological filtration do best in an oxygen rich environment, which is facilitated by the wet/dry filter. After the water drips over the media it goes to the bottom of the filter where it is pumped back into the aquarium. In addition to the biological media, chemical media can be placed in the bottom of the wet/dry filter as well. These filters tend to be fairly costly and can require a bit more attention, but can be an excellent choice if you have the necessary resources. The final filter I will mention here is the fluidized sand bed filter. These are in most cases only mechanical and biological filters and have no chemical aspect. Most commonly available in the aquarium hobby, they are designed to hang on the back of your aquarium. These filters are chambers that hold very fine grain quartz sand, and function primarily in a biological capacity. The premise is that the sand grains are capable of harboring large bacteria populations, water is circulated though the chamber containing the sand and hence exposed to large populations of nitrifying bacteria. Set up properly these are great biological filters, however it can take a bit more tweaking to adjust properly. Both wet/dry filters and fluidized sand filters can be great for large freshwater and marine aquariums.

The Wet/Dry filter is an excellent choice for certain applications, not well suited for all aquarium types.

Although not a filter in the true sense of the word one other piece of equipment that is appropriate to mention in this section is the foam fractionators more commonly referred to as protein skimmers. This particular piece of equipment is generally only used in saltwater or highly brackish aquariums, as it will not function properly in freshwater. If you have ever stood on the beach and watched the waves crash in, then you may have noticed how salt water sometimes forms foam where it crashes onto the shore. Have you ever seen this in a freshwater lake?? Probably not. Well this is why a protein skimmer works in saltwater, but not fresh, it is all in the foam. Saltwater has certain properties that cause it to foam when aerated. So let me now explain what a protein skimmer is, how is works and what advantages it offers. Although they come in many shapes in sizes a typical protein skimmer is some sort of large tube. Air is generated in this tube causing small bubbles to form. The bubbles rise up the column and begin to form frothy foam at the top of the tube. Water is continually pumped through the column and back into the aquarium. The key to what a skimmer does and how it works are the bubbles formed in the skimmer tube. These bubbles are generated usually either by an airstone and airpump or a pressure valve called a venturi valve. The bubbles act as what we would call an interface, meaning that certain things are attracted to the bubbles. Basically proteins, lipids, fatty acids, amines, fecal matter and nitrogenous waste are attracted to the oxygen interface the bubbles offer. As the bubbles rise up the column the waste products are carried up to form the foam. The foam overflows into a collection chamber and thus much of the waste and waste byproducts are removed from the aquarium. By removing many of these waste product before they enter into the nitrogen cycle improved water quality is the result. So although only of value in a marine or brackish aquarium a protein skimmer a great way to ensure high quality water necessary for these environments.

A Protein Skimmer works by creating tiny bubbles, which act as an interface to remove proteins and waste from the water.

To keep the temperature stable in your aquarium it may be necessary to have a heater or even in some cases a chiller. In most cases a heater is all that is necessary to maintain the proper temperature, however in special cases such as reef aquariums a device called a chiller that prevents the water from getting too hot may also be employed. In most freshwater aquariums a simple basic heater will do the trick. As far as what size or wattage heater to purchase this can depend on a number of factors such as: room temperature differential (how much colder is the room the tank is in when compared to the desire temperature of the aquarium), size of the aquarium, and others. However to make it simple I would generally suggest a 3-5 watts per gallon, for instance a 10-gallon tank a 50 watt heater or a in a 30-gallon tank 100-150 watt heater should suffice. Obviously, if you have any special circumstances that may warrant the need for a large or smaller heater consider these before your purchase. Although virtually any aquarium heater will work for a freshwater aquarium I would consider a very high quality heater for a marine aquarium. I would suggest looking for a model that is fully submersible and thermostat controlled for the marine aquarium. Simply put electricity and saltwater don't go well together and the submersible design is very tightly sealed to prevent possible problems. Additionally, many of the submersible designs are a bit easier to control with regards to adjustment of the temperature. Most submersibles

have a temperature dial to select the appropriate temperature for your aquarium, while many non-submersible type heaters only offer "+" and "-" adjustment controls. With regards to a chiller, this is a piece of equipment that is only going to be used in very specific circumstances so I am not going to go into great detail here. Basically a chiller is a compressor and refrigeration coils, usually made from titanium, that is used to cool water that may become too hot for sensitive reef corals and animals. The chiller is a very expensive piece of equipment and not commonly used except by reef enthusiasts.

Now that we have covered the majority of the major equipment needed to set up an aquarium lets look at some of the smaller but also important things we still need to set up our aquarium. A thermometer, even if your heater has a built in thermostat I still suggest having a separate reliable thermometer. Gravel, you will want some sort of substrate to cover the bottom of the aquarium. If you are setting up a saltwater aquarium you may want to choose a substrate like crushed coral, dolomite, or aragonite which also adds the benefit of helping to maintain the high pH required in marine aquariums. However, as a rule you want to avoid those materials (crushed coral, dolomite and aragonite) in a freshwater aquarium as the pH increase could lead to excessively high pH. I suggest avoiding silica-based sand, as this can lead to blooms of certain types of algae, such as diatom algae. In a freshwater aquarium simple aquarium gravel is probably your best choice. Although we will cover this in more detail later, it is also wise to purchase a good water testing kit. With this you should have everything you need to start setting up your aquarium other than water, fish and any decorations you might want.

CHAPTER FIVE

So you have purchased all of your aquarium equipment and now you're ready to begin setting up your new aquarium. The first consideration now is where to place your new aquarium. There are two primary considerations involved in placing your aquarium temperature and sunlight. Ideally you should avoid placing your aquarium directly in the path of air-conditioning or heating vents. Placing the tank too close to such vents can result in rapid temperature changes that can be stressful on the fish. Also you want to avoid placing the tank in an area where it will receive a lot of direct sunlight. Should the tank be subjected to high amounts of direct sunlight you may have problems with excessive algae growth. Additionally you should avoid placing the aquarium in a high traffic area, such as a hallway, this can be stressful on the fish since there is always so much commotion. Now that you have chosen a location place, your empty aquarium onto a suitable aquarium stand. Make sure that there is adequate room behind the tank to accommodate the space needed by the filter or any other accessories that may hang on the back of the tank.

Before filling your aquarium with water it is advisable to wash the tank out with warm water. Once the tank is clean and placed back on the stand we can begin to put the gravel or substrate into the tank. It is never a bad idea to rinse the gravel before placing it in the aquarium. If you are dealing with a small quantity you can simply pour the gravel into a colander and rinse it lightly under the faucet. However if you are dealing with a large quantity of gravel a five-gallon bucket and a garden hose may work better. If you use a bucket make sure that the bucket is clean and has not been used to hold any household chemicals or cleaning supplies. Your best bet is to purchase a bucket that will only be used to fill or drain your aquarium. Rinse the gravel in small batches and add it carefully to the bottom of the empty aquarium.

At last it is time to begin filling your aquarium with water. I will discuss two slightly different variations for filling your aquarium with water one for freshwater and one for brackish and saltwater. It is important to add the water slowly to prevent excessive clouding of the water. One thing we can do to prevent the tank from becoming cloudy when the water is added is to place a dinner plate in the tank on top of the gravel. When you pour water into the tank you will gently pour it over the plate this will prevent dust from the gravel from mixing with the water.

When adding water to fill your freshwater aquarium you can add the water directly to the aquarium using a bucket or a hose designed to fill your aquarium like the Python Clean and Fill. I suggest that you use water that is close to the target temperature (70-80 degrees for example in a tropical aquarium) for the aquarium to fill the tank. This means checking the water temperature with a thermometer before you add it to the tank. Certainly the temperature does not need to be exact, but the closer it is to the target temperature the sooner it will stabilize. Once the tank is 80-90% filled stop and add any aquarium decorations you may have such as plastic plants, driftwood, ceramic ornaments, or large rocks. Once this is done I would suggest checking the pH of the tank water. If the pH needs adjusting you will want to add the appropriate product to raise or lower the pH. At your local aquarium or pet shop you will find products designed to change your pH. I would recommend buying the dry chemicals, to adjust your pH, which tend to be more concentrated than liquid pH adjusters. Sodium biphosphate works well to lower the pH and sodium bicarbonate is a great way to raise a low pH. If sodium bicarbonate sounds familiar it is because this is baking soda, which can be used to raise pH as well. Once the pH is adjusted to the proper level it is time to start our filter, heater, airpump and any other equipment we will be using on the tank. Before starting any of your equipment make sure that you have thoroughly read any directions provided. It is likely that you will need to fill your hang on back power filter or canister filter with water before you plug it in so that it can begin operation. A heater should be properly placed in the aquarium paying special attention to any indicators on the heater that show the suggested water level. Your heater should sit in the tank 20-30 minutes before you plug it in to prevent damage to the heater. Now that all of the equipment is functioning properly the final step is to add any other water conditioners that may be needed. Most likely you will want to add some sort of general water conditioner to remove chlorine or any heavy metals. There are many products that do this such as: Start Right, Genesis, Stress Coat and a host of others. Now fill the tank the rest of the way. At this point I would not add any fish until the tank sits for 24 hours so that you can check for any possible leaks or problems with the equipment. Congratulations you are now most likely only a day away from having your first fish.

Quality synthetic sea salt are an excellent method to produce a consistant quality of saltwater for an aquarium.

Setting up a saltwater tank is done in a similar way with one primary exception, mixing the salt water prior to adding the water to the tank. For this task I would urge you to purchase a 5-gallon bucket. The idea is that you want to mix the salt and the water completely before adding it to the aquarium. So calculate the amount of salt that will be necessary per five gallons of water and add the salt to the bucket. Then fill the bucket half way up with the proper temperature water. Next mix the salt and the water until all of the salt is completely dissolved, stirring the mixture by hand can do this. Once all of the salt is dissolved pour the bucket of water gently into the aquarium over the plate as mentioned previously. Again fill the tank about 80-90 percent, add your decorations, start your filter, adjust the pH and add any necessary water conditioners. Now finish filling the aquarium, wait 24 hours to ensure no leaks and you are ready to go.

CHAPTER SIX

The day that the aquarium was set up you should have tested the pH of the aquarium water. Even if the initial water test showed an appropriate pH it is advisable to test the pH again prior to adding fish. It is always best to achieve the proper pH before adding any fish, since changing the pH once fish are added can be stressful on the fish even when it is necessary. As mentioned previously you will need to get the appropriate chemical to raise or lower your pH as needed. It is important to note that you need to make sure that the chemical(s) you choose should be appropriate for the type of tank you have set up. Not all of the chemicals you might use in a freshwater aquarium are safe in saltwater aquariums.

In some cases it is difficult to adjust the pH of your aquarium after adding the appropriate chemicals to raise or lower it. Often this is due to hard water. When there are many dissolved minerals and heavy metals in water can lead to hard water, and can be very difficult to adjust the pH. If you are experiencing problems with a high pH in a freshwater aquarium you may want to purchase a water hardness test kit. This will tell you if hard water might be your problem. Also it is important to make sure that you have added nothing to the aquarium that may have induced the pH problem. A freshwater aquarium should contain NO seashells, coral skeletons, or carbonate based rocks as these items are all composed of calcium carbonate that can slowly dissolve and lead to an increase in water hardness and pH. As a general rule if something has come from an ocean or other saltwater environment you should not placed it into a freshwater aquarium. If you find that you have hard water there are several things that you can do to deal with this problem. One is to find an alternative source of water, this could mean using bottled water or bringing water from a different location. Another option is to purchase water-softening agents. There are chemical resins available that can soften the water, these come in various sizes and can work well on aquariums less than 75 gallons. If you have a very large aquarium or many aquariums and have a problem with hard water you may want to consider a water conditioning system such as a de-ionizer or reverse osmosis (RO) system.

A quality test kit is a must for every new aquarium owner.

Although the water was tested prior to adding fish and the pH was adjusted to the appropriate level this is only a small part of water testing. Once living organisms are added to an aquarium the chemistry of the water will change and we will need to test the water more extensively. Of course living animals eat and therefore secrete waste, this waste takes the form of nitrogen, and can actually be toxic to the fish. The primary waste product of the fish is ammonia (NH_4). Ammonia is extremely toxic to fish and would eventually kill all of your fish if it continued to build up in the aquarium. However, in your aquarium as in nature a bacteria population (*Nitrosomas sp.*) will form that will convert the ammonia into a less toxic substances known as nitrite (NO_2). While the nitrite is toxic, it is not nearly as toxic as the ammonia. Although like the ammonia if nitrite were to continue to concentrate in the aquarium, it could quickly reach toxic level, resulting in nitrite poisoning. As was the case with the conversion of ammonia to nitrite bacteria (*Nitrobacter sp*.) convert the nitrite into a less toxic substance known as nitrate (NO_3). The nitrate resultant from this process is approximately 200 times less toxic than the initial ammonia waste product. This process we just described is known as nitrification. Although the nitrate is not very toxic, if it were to build up for a long period of time it could pose a threat to the fish, this is one of the reasons that regular partial water changes are so important. This process of nitrification is exactly what happens in the natural world. However in nature no one does regular water changes on our lakes, river and oceans. How then is nitrate prevented from building up to toxic concentrations in nature? The first way in which nitrate is prevented from reaching high concentrations is due to live plants. Live plant use nitrogen as a fertilizer; therefore live plants help to prevent nitrate blooms in nature. Additionally in nature another process called de-nitrification occurs. De-nitrification occurs in anaerobic (without oxygen) conditions such as the mud that forms a riverbed where there is very little oxygen. Anaerobic bacteria actually convert the nitrate to nitrogen gas (N_2) and nitrous oxide (N_2O_2), which are both gases that rise up through the water column and are diffused into the atmosphere. Combined the processes of nitrification and de-nitrification form the nitrogen cycle (see figure 1). This concept of the nitrogen cycle is one of the most important concepts to understand when it comes to successful aquarium management.

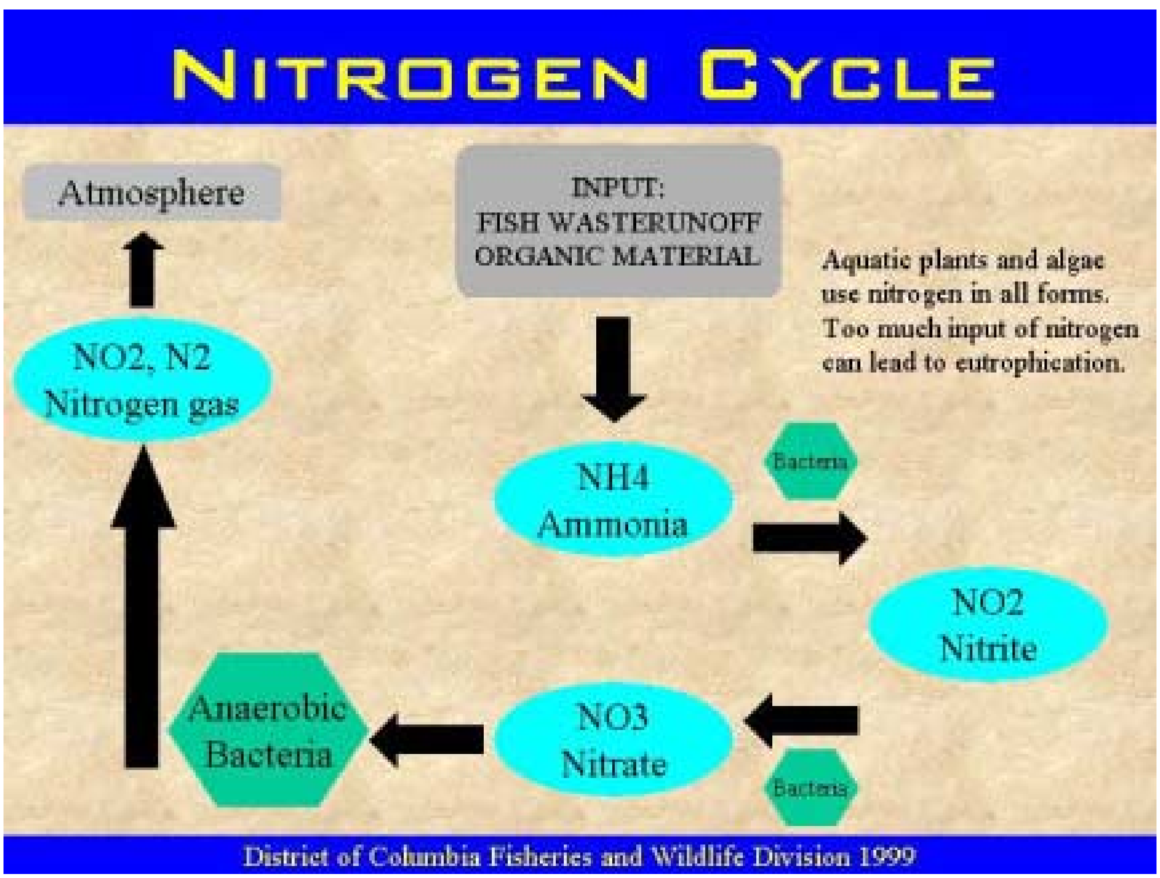


Figure 1
The nitrogen cycle is perhaps one of the most important concepts to understanding closed system aquarium dynamics.

Since nitrogenous waste (ammonia, nitrite and nitrate) can be toxic to fish it is important to monitor and control these chemical waste products. Test kits can be purchased to test for all of these. It is especially important to test these parameters while the aquarium is in the initial break-in or “Cycling” phase after being set up. When the aquarium is first set up there are no bacteria to aid in the conversion of the nitrogenous waste from very toxic material to an almost non-toxic state. Therefore it is very important to test the water in a new aquarium for ammonia while the bacteria population develops. Once the initial ammonia begins to dissipate, as the bacteria begin reproduce, you will begin to see nitrite build up finally the nitrite will begin to decrease and nitrate will start to build (figure 2). This initial phase of an aquarium is often referred to as the “Cycling” period. Cycling is the process in which bacteria reproduce to sufficient populations to breakdown the nitrogenous waste produced by the fish. Cycling also occurs every time you add new fish to your aquarium you increase the amount of waste secreted and hence the bacteria populations must increase to keep up with the increased level of waste. During the first few weeks after setting up your new aquarium you should test for ammonia at least bi-weekly and once the ammonia begins to drop begin testing for nitrite and nitrate.

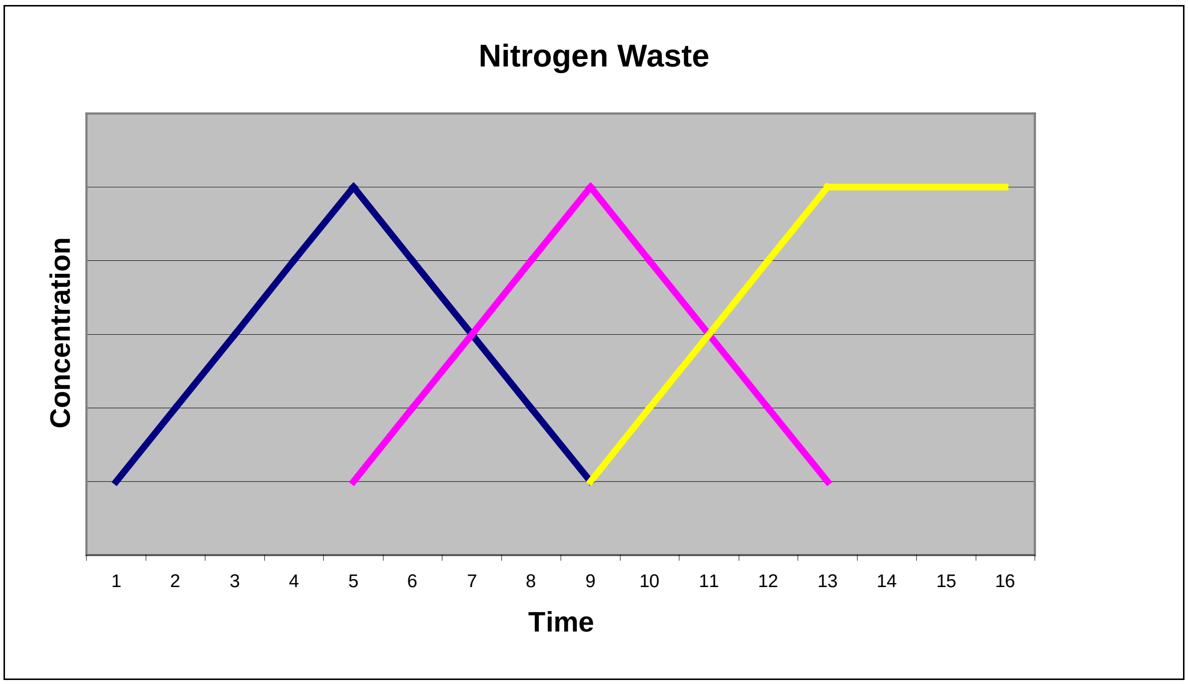


Figure 1
In an aquarium ammonia (blue line) builds up first and is gradually converted to nitrite (pink line), which is finally converted to nitrate (yellow line).

There is of course just one type of aquarium upkeep that needs to be done on a daily basis, and that is feeding. Ideally fish should be fed daily, however fish can survive for weeks without eating so don’t worry about the weekends your fish will be fine. When it comes to fish nutrition there are many good well balanced prepared foods on the market. Most of these foods are fine as a staple diet, however I do suggest occasionally offering you fish some variety. Generally fish with more diverse diets will show greater coloration and better growth. Many aquarium and pet stores carry frozen and live foods, such as brine shrimp or blackworms, these are great treats for you fish, but of course remember moderation is important. On the topic of moderation we should discuss how much to feed your fish. If you were to read the label on many brands of fish foods, you would see labels that read: "Feed your fish as much as they will consume in five minutes, two to three times daily". What does this mean? Do you drop one flake or pellet in after another for five minutes? Well first of all the five-minute suggestion is very ambiguous, and could lead to trouble if one tried to feed such a quantity. Overfeeding is a major problem to many new hobbyists, and anyone that tried to feed their fish as much as they could eat in five minutes could potentially have problems. Remember the nitrogen cycle, food even if uneaten breaks down into nitrogenous waste and could lead to problems for the fish. Basically the companies that produce fish food generally suggest feeding more than I would. The reason, they sell fish food, they would be happy if you fed a cup a day. My suggestion is that fish should eat once or twice daily. You should feed a reasonable quantity. Generally my suggestion on how much to feed would be dependent on two main factors: the number of fish and their sizes. For most small (under 2 inches) fish I suggest three to four flakes or pellets per fish no more than twice a day. An extra flake or pellet per inch of length should suffice for larger fish. These guidelines I have given are just that, they are not designed to be rules only suggestions. You need to increase or decrease you feeding as signs suggest. If you realize you continually have a lot of uneaten food left in the aquarium, you will want to decrease the amount you are feeding. If your fish appears to be emaciated or losing body mass you should increase the quantity of your feedings. The key is to be sensible, and beware of overfeeding. One last note on the topic of feeding that may be of significant importance, especially for teachers, is the automatic feeder. Automatic feeders are devices that attach to the aquarium that can feed your fish automatically for several weeks. This makes feeding a breeze and is beneficial for those that cannot always be there to feed their fish.

utomatic fish food feeders are a convenient way to feed you fish even when you can't be there.

Of course regular water testing and feeding are two important aspects of aquarium management. However, perhaps the most important aspect of maintaining your aquarium is performing regular water changes. Here I will provide some general guidelines for a schedule of maintenance, however every aquarium is unique and these guidelines may not apply to every aquarium setup. Generally what I recommend to most aquarist are small monthly water changes. Generally speaking a 25-30% water change once a month is all that is necessary to ensure proper water chemistry. Water changes should be performed using an aquarium siphon, which will pull dirty water from the gravel bed where most of the waste accumulates. If you were to simply scoop water from the top of the aquarium you would be taking the cleanest water from the aquarium. So it is always best to siphon the water directly from the bottom, where you can remove a greater percentage of waste. Prior to starting your water change, I suggest unplugging your heater (if the heater is not unplugged it may crack

Aquarium siphons are a great tool for doing water changes.

when exposed to air of a different temperature) and scrubbing the algae from the inside walls of the aquarium with an algae sponge. Simply use the siphon to drain 25-30% of the water out of the aquarium into a clean (chemical free) bucket. After the water has been removed from the tank, it is now a good time to check your filter. I suggest removing the biological media and rinsing gently in the bucket of water, which was drained from the aquarium. Why rinse the biological media in dirty water you may ask? Well simply to ensure that we do not kill the beneficial bacteria populations that inhabit the media. After all the primary purpose of a biological media is to provide surface area for bacteria. If you were to clean the media under tap water, you may lose a significant number of bacteria due to differences in water temperature, chemistry and perhaps the presence of chlorine. The idea when cleaning any biological media is not that it is perfectly clean, but that major debris is removed from the surface. If your filter uses a chemical media, such as activated carbon, I would suggest changing this every two to three month or as needed. When you refill your aquarium make sure that the temperature and pH of the water to be added is close to that of the water in the aquarium. Of course if your aquarium is saltwater you will need to add the appropriate amount of salt to the water, prior to filling the aquarium. Also it is important to make sure that you use a clean bucket or container when adding freshwater or saltwater to the aquarium. You want to make sure that the bucket or container you use is used for nothing else, it should only be used to add water to the aquarium. The reason I stress this is that if you were to use the same bucket to fill the aquarium that you used for mopping the floors of your house, the bucket may have chemical residue that could lead to fish loss. Anything that is used in or on your aquariums should be cleaned with nothing other than warm water or a very dilute bleach solution. Most household chemicals are toxic to fish and caution should be used when using any chemicals near your aquarium. After the tank has been refilled water test should be performed and corrective action taken as needed. One other word of caution regarding water changes; do not think if you miss a month of doing water changes that you should do a larger volume water change the next. Remember the nitrogen cycle, it is always preferable to do less volume more often than more volume less often. As an excessively large water change (over 50%) will likely result in fish mortality, it is best course get on a regular schedule for performing your changes. Additionally do not think that replacing water that has evaporated from your aquarium constitutes a water change. During the course of the month between water changes, it is likely that you will need to add water to the aquarium, as water will evaporate. This does not accomplish the same thing as a water change. In fact when water evaporates, generally only pure water will evaporate. This means that chemical and biological waste (nitrogenous waste) will in fact concentrate in an aquarium if water is only added and not taken out through regular water change. One other note on evaporation for those of you with saltwater tanks, when water evaporates the salt will remain in the aquarium so you can usually just add freshwater to top off the aquarium when filling to adjust for evaporation.

One final topic I want to address regarding the maintenance of your aquarium is algae. Algae can become a major problem in an aquarium if the tank is not properly maintained. However some algae in an aquarium is not a bad thing. In fact much like live plants algae will utilize nitrogenous waste as fertilizer and release oxygen. However, too much algae certainly will make the aquarium less aesthetically pleasing. We have already discussed the importance of regular water changes and this is an important factor in preventing your aquarium from becoming overgrown with undesirable algae. Water changes help to remove nitrogenous waste from the aquarium, which essentially helps to eliminate a potential source of nutrients for algae. Algae require three factors for growth and survival: nitrogen, phosphorus and light. The nitrogen is a byproduct of living organisms, as it is produced as a waste product. Phosphorus is also a component of fish waste and fish food. The aquarium light, as well as from ambient sunlight that may reach the aquarium, supplies light to the aquarium. The key is to control the factors that cause algal growth. Light can be controlled by placing the aquarium lighting fixture onto a simple household timer, the timer can turn the light on and off at regular intervals. I suggest a rule that you provide 8-10 hours of light per day to your aquarium, this is sufficient for the animals that reside in the aquarium without being so much that algae will over run your aquarium. As far as controlling the nitrogenous waste in your aquarium, you should take precaution not to overfeed your fish and also keep to a regular schedule of water changes. Additionally test your water at least monthly for nitrogenous waste (ammonia, nitrite, and nitrate) to ensure that it is not accumulating to high levels. If you find that your nitrogen levels are high, then a series of small waters changes (<10%) should help to reduce the concentration. Additionally assess your feeding to ensure that you are not feeding too much, as the break down of excess food contributes greatly to nitrogen levels. Generally too much light and high levels of nitrogenous waste are easily prevented through proper aquarium management. However, phosphorus can be a bit more difficult to control. Phosphorus is often in the source water you use to fill your aquarium. If the phosphorus in the water you fill the aquarium with, you may need to use a special chemical resin to remove it from the water. Test kits are available to test for phosphorus, however, I would only purchase one if after reducing the levels nitrogenous waste and the photoperiod (the amount of time your aquarium light is on) you still have an algae problem.

Other methods to control algae include: snails, fish that eat algae, and live plants. One of the most popular fish to help keep your freshwater aquarium clean and free from excessive algae growth (especially on the glass) is the Plecostomus or Suckermouth Catfish. These fish are herbivores and do a great job on algae control. However do not get one in a new aquarium until some algae growth has occurred otherwise there will not be adequate food for the fish. Also if there is little algae in aquarium you may need to supplement the Suckermouth's diet with other vegetable material (cucumber is a good alternative food). A snail is another good algae eater in the aquarium, but avoid putting them in aquariums that house aggressive fish. In a marine aquarium Asteria and Turbo snails are commonly used. Tangs are a marine fish that can help to control some of the hair-type algae common to marine aquariums. Live plants are another great way to help control algae. Basically live plants use the same things as nutrients (nitrogen and phosphorus) that algae require. By keeping live plants the plants in essence are able to out-compete the algae for the available nutrients. Remember though that live plants do have special needs such as the right type of lighting and micronutrients such as iron. Therefore I do not suggest the plants as a primary way to prevent algae. Only keep live plants if you are willing to put a little extra work into the aquarium, that is necessary to ensure that the plants will survive and thrive.

CHAPTER SEVEN

Before embarking on a discussion about disease recognition and treatment, it is important to first discuss a vital concept of aquarium management: “Prevention, Prevention, Prevention”. As with human health, if not to an even greater extent when dealing with fish, preventing health related problems is always easier than curing existing problems. The question becomes: “how do we prevent health related problems in fish?” Perhaps the best way to prevent potential problems is by always ensuring that the environmental conditions are correct for the fish. To ensure that the environmental conditions are correct water tests can be performed. Through my experiences I have found that the most common cause of poor fish health is improper water quality. Poor water quality does not necessarily mean that the water used to fill the aquarium was of a poor quality, but rather what it most often means is that due to poor aquarium management techniques (i.e. not performing regular water changes or overfeeding fish) organic waste (i.e. Fish waste, excess food) have built up to toxic levels that become very dangerous to the fish. In my years of working in the consumer aquarium industry I saw many clients who came in to discuss a wide variety of fish health problems. The first thing I would do, when talking to these clients, was to try to identify the nature of the problem. In many cases a description of the symptoms would be sufficient to diagnose the problem. Upon reaching a diagnosis most clients expected me to then recommend a course of treatment, however I would seldom recommend treatment options until I could determine the cause of the problem. In an effort to determine the cause of the problem I would next perform water test on a sample of water from the aquarium that housed the ailing fish. In this testing process I would generally test for nitrogenous waste (NH_3, NO_2, NO_3) and pH. In some cases depending on the symptoms I would perform other test as well. After completing the water test I would often find the cause of the problem was poor water quality, the symptoms or disease was the consequence. Basically a healthy fish is generally fairly resistant to many common problems such as bacterial infection, fungus and parasites. The fish has a protective covering called a slime coat, however when poor water quality exists in an aquarium a fish’s slime coat becomes thin and the fish's ability to fight off disease, infection and parasites is greatly compromised. In fact, in many cases when water quality is improved a fish will often heal with no medication due solely to the improvement of environmental conditions and the regeneration of a healthly slime coat. However, keep in mind that like many other things in life there are no quick fixes here. Improving water quality sometimes takes a bit of time, and may require doing several small water changes over the course of a week or so. Do not try to rush things along, do not think “well if the water quality is bad I'll just change all the water and everything will be fine” remember the nitrogen cycle, if you try to do too much too fast you will often do more harm than good. The bottom line here is to stress the importance of good water quality, when quality of the water deteriorates the fish will likely follow. It is always a good first step to perform water test anytime you have an ailing fish.

The first common fish health problem that many people encounter is something we call “New Tank Syndrome”. When many new aquarium hobbyists get started in the hobby, they make a very common mistake, which is simply too much too soon. “New Tank Syndrome” is a problem that occurs when too many fish are added to new aquarium, before sufficient bacteria populations exist to break down the potentially toxic waste of the fish. Within a three to four days of adding too many fish at once to the tank, the tank becomes cloudy, a day or two later many of the fish may be seen swimming at the top of the aquarium gasping, and if not corrected fish can begin to die due to ammonia toxicity. The reason “New Tank Syndrome” occurs is because often people are misinformed or uniformed when they initially set up their aquariums. When shopping for a new aquarium, a common question people ask is: “How many fish can I put in this tank?”. The response, from a typical pet store employee is often something along the lines of: “About one inch of fish per gallon of water” a well informed employee may even distinguish that in a saltwater aquarium you would even have a lower stocking density. However, these loose guidelines that are often given can be very misleading to the novice hobbyist who then rushes to pick out all of the new fish for the aquarium. First of all does one inch per gallon mean if you just purchased a 10 gallon aquarium that you can rush out and buy ten; one inch fish? NO! There are a lot of different factors that must be considered when adding fish to an aquarium. While the fish may only be a one-inch fish the day you buy it, how big can it potentially get at maturity? While many believe a myth that says that fish only grow as big as their environment will allow, this is not necessarily the case. Fish, just like people have genetics that dictate their growth. Does a person that lives in an apartment not grow as tall as one that lives in a mansion? Of course not, similarly fish do not wake up one day and say “Hey this is only a ten gallon aquarium, I better stop growing!”. Now there is a hint of truth behind the myth, that being as a fish grows larger and larger it makes more and more waste, the waste builds up to highly toxic levels and eventually the fish dies a premature death. What other reason might we not want to add all of the fish to a new aquarium all in one day? THE NITROGEN CYCLE! Remember in the discussion of the nitrogen cycle in chapter 5, that it is important to slowly add fish to your new aquarium so that beneficial bacteria populations can reproduce to sufficient numbers to break down the waste of all the fish. If too many fish are added at one time bacteria cannot reproduce quickly enough, before fish waste builds to a toxic level resulting too often in massive fish loss. Although “New Tank Syndrome” can be a deadly problem, it can be easily avoided if the tank is stocked gradually.

Perhaps the next most common problem encountered by aquarist is a parasitic infestation commonly referred to as white spot disease or “Ick”. This is a protozoan parasite that begins by infecting the gills of the fish, resulting in the fish having difficulty obtaining enough oxygen, and if left untreated can cover the fish resulting in the death of the infected fishes. White spot disease occurs in both marine and freshwater aquariums, although it is a different protozoan parasite in each case responsible for causing the disease. In freshwater aquariums parasites of the genus *Ichthyophthirius* are responsible, while the marine equivalent is of the genus *Cryptocaryon*. The symptoms of the disease include: small white spots that appear on the body in fins of the fish. These spots resemble small grains of salt. Although white spot disease is curable, if it is not detected early it can be fatal. Common treatments for the condition include: foramlin, copper,

Formalin is the primary ingredient of many medications for white spot disease.

quinine and other anti-parasitic agents. The biggest concern, aside from water quality, when deciding on an appropriate medication is what creatures you have in your aquarium. Certain medications are toxic to specific types of fish. In some cases dosage adjustments are needed if your aquarium houses certain types of fish. An example of this would be you formalin based medication, in which case it is recommended that a half dosage is used if your aquarium contains tetras or scaleless fish (such as catfish). In marine aquariums copper is commonly used to fight white spot disease, however in marine aquariums that contain invertebrates (such as corals or snails) copper is not recommended since it is highly toxic to most invertebrates. In addition to medication other ways of treating white spot include changes in salinity and temperature. A slight change in salinity (adding a small amount of aquariums salt to a freshwater tank, or mildly diluting the salt concentration in a marine aquarium) can affect the osmoregulation of the protozoan parasite and often eliminate it. Likewise a mild increase in temperature can often cure mild cases. However I would not recommend these treatment options to novice aquarium hobbyist as the tank could quickly become overwhelmed if not properly monitored. Therefore, while white spot disease is highly curable if detected early it is important that caution be used when choosing a medication.

Another condition similar to marine white spot disease that occurs in marine aquariums is marine velvet (*Amyloodinium*). Like white spot marine velvet is a protozoan parasite, and again the first symptoms often include respiratory distress as the condition generally begins in the gills. Another common symptom is a behavior known as flashing. Flashing is when a fish scratches their body on objects in the tank such as rocks or gravel. The primary difference between white spot disease and velvet is the speed at which velvet can develop. From the time the first symptoms appear mortality can occur within three to four days. Additionally in the advanced stages the white spots are so numerous it almost appears as if someone has sprinkled baby powder on the fish. The treatment for velvet is similar to the treatment for white spot. Common medications include: quinine, copper, formalin and malachite green. Freshwater bathes are often used to treat individual fish. A freshwater bath involves removing a fish from a marine aquarium and placing the fish into a container of freshwater for a short period of time. While in the freshwater many of the parasites are killed due to their inability to adjust to the osmotic difference of the freshwater. Freshwater bathes can be very effective, if properly performed, however I would suggest that they only be used as a last resort and only performed by an expert hobbyist as the treatment can be dangerous to the fish.

Medications are available in your local pet and aquarium shops.

Fungus infections are another problem that can affect both marine and freshwater fish. Although fungus infections are not uncommon it does seem that fish have a fairly high natural resistance to fungal infections. Fungus infections can occur both internally and externally, however the latter is much easier to recognize and treat. In the case of external fungus infection often symptoms include a thick coating of film on the fish or in some cases cottony tufts near the mouth and fins of the fish. There are many medications on the market to counteract such fungal infections, but it is also important to make sure the water quality is good in the aquarium. Internal fungus infections can be hard to initially diagnose, however symptoms of advanced infections can be very extreme. In the advanced stages of the infections the fish will often swim upsidedown or in loops as equilibrium is affected. Additionally, popeye can develop in which one or both of the eyes appears to be popped out from the socket. In late stages of an internal infection dropsy may also develop, which is when the body becomes filled with fluid and the scales of the fish tend to stand up on edge. Although many medications exist to deal with the advanced stages of internal fungal infections, often it is nearly impossible to recover after the infection has reached a certain stage. Therefore, if you suspect an internal fungus infection you will want to start a regime of medications as soon as possible. Anti-Fungal agents are available for aquarium use from many manufactures; check your local aquarium or pet shop for availability.

Bacterial infections are another common aquarium illness. Of course bacteria exist everywhere and an aquarium is no exception. Fish, by their nature, have a relatively high resistance to bacterial infections. However, when fish become stressed, due to poor water quality, harassment by another fish or even during transport, they become much more likely to develop bacterial infections. When the fish becomes stressed the slime coat thins and bacteria can attack the fish. The symptoms of bacterial infections can take many forms some of the more common symptoms include: frayed or tattered fins, rapid respiration, grey film over the eyes, bloody scales, and open lesions. While some bacterial infections can result in mortality in just a few days, most will persist for a couple weeks before death becomes eminent. Treatment for bacterial infections can depend on a number of factors, but most important is to determine whether the bacteria are Gram-negative or Gram-positive, this is often apparent by the symptoms. The Gram status is related to the structure of the cell membrane surrounding the bacteria. A Danish physician, Christian Gram, developed the terms Gram-negative and Gram-positive while working on a bacteria-staining technique. The importance of the delineation of the Gram status is that it is related to the way in which antibiotics affect bacteria. Many of the bacterial infections that affect fish are Gram-negative and antibiotics such as penicillin and sulfa drugs are not effective, while


Above: A fish with an advanced internal bacterial infection. Note the swollen body associated with the condition known as Dropsy and the eyes appear to be popping out of the sockets (popeye).

erythromycin and tetracycline can be quite effective. Again as with any other illness water quality conditions should be checked if a bacterial infection is suspected, as poor water quality can be the stressor that facilitates the bacterial invasion.

Although there are many more illnesses for which marine and freshwater fish are susceptible, the most common are those previously mentioned in this chapter such as bacteria, fungus and parasitic infections. However the importance of good water quality should again be emphasized, as good water quality is often the key to disease prevention. Additionally I would suggest the purchase of a good reference book (see Chapter 10 for suggested reading), which will cover the topic of disease in greater detail.

CHAPTER EIGHT

An aquarium is not only an attractive addition to the classroom, but can also be used as an instructional tool for a variety of topics (Science, Math, English, Geography, Art, etc). Of course the potential use for science may seem a natural association, as an aquarium can easily be used to teach topics such as: fish biology, nitrogen cycling, ecosystems, habitat, the food chain, photosynthesis, pollution, plant biology, anatomy, genetics, scientific nomenclature or scientific methods.

How might an aquarium be used to teach geography? Let's assume you have set up an aquarium, with various species of tropical fish. As a project the class could determine the natural place of origin of the fish and then indicate on a blank world map were the fish are indigenous. What about math? How could an aquarium be used to teach a topic like math? Imagine now you had a well-stocked 55-gallon aquarium filled with fish. Let's assume for a minute that your aquarium housed 10 Neon Tetras, 8 Rummynose Tetras, 5 Swordtails, 2 Angelfish, 1 Cory Catfish, and 1 Pleco. What you could now do is use the fish to teach about fractions and percentages. Have the students determine what fractional value each species composed of the total population. Next have the students convert the fish fractions to percentages. In a subject like creative writing, the fish tank could be the topic of assignments. In an art class the aquarium could be used as students painted a picture of their favorite fish.

As you can see there are many potential uses for an aquarium in the classroom. As educators your task is to find creative ways to incorporate the aquarium into your curriculum. As many of you can attest, students learn best when they have an interest in the topic and can get hands-on experience, and what better way to stimulate interest than with an aquarium. There are many books available from your local teacher supply shops that carry lesson plans that involve aquariums and aquatic organisms. Additionally the Internet is a great resource for information and even lesson plans. Tetra Inc., has an interesting website that features lesson plans for teachers, that deal with aquariums. In the next three pages I will include an example taken directly from the Tetra web site lesson plans.

Observing Fish Behavior
(Over a Short Period of Time)

Objective:

The student will be able to describe some typical fish behavior based upon observations of aquarium fish during a 5-10 minute period.

Materials Needed:

- Watch with second hand or class clock with second hand
- Aquademics™ Science Worksheet #2 (one per student)
- Paper and pencil for each student
- Backgrounder on Animal Behavior (for the teacher or parent to review)

Activity:

Review the Backgrounder on Animal Behavior.

Ask the students to make a brief profile of their own behavior during a typical day. Pose questions such as:

1. Do they like to play alone?
2. Do they like to play in groups?
3. Do they eat one type of food at a time or mix it together?
4. Do they like to play quiet games or active games?

Tell students that aquatic scientists spend lots of time (hours and hours!) observing fish and recording data about their observations. Today, each student will become an aquatic scientist.

Students will work in pairs for this lesson plan. Each pair will pick any fish in the Aquademics™ aquarium and observe it for 5-10 minutes. One partner calls time every 15 seconds and records behaviors listed on Aquademics™ Science Worksheet #2. The other partner describes what the fish is doing when time is called.

Distribute Aquademics™ Science Worksheet #2 and go over the list of possible fish behaviors. Show students how to make a "tic" mark on each line if that particular behavior is observed. Tell students NOT to guess at the fish's behavior if it is in a crevice or missing from view at the time interval; in this case, they should place a "tic" mark on the line for NOT SEEN.

At the end of the specified time period, ask student groups to tally their "tic" marks and to make a graph showing the frequency of various fish behaviors. Invite them to comment on and discuss which behaviors were seen and why.

Each pair should have at least 20 "tic" marks at the end of the specified time period.

Result:

Have students draw the outline of a fish on a blank piece of paper. Ask them to write at least four different observed fish behaviors inside the outline.

Animal Behavior

Animal behavior is a diverse area of study that looks at the organization of a single animal or even its cells but also compares group dynamics and adaptations over time. People who study behavior look at these different levels. An endocrinologist looks at how hormones dictate behavior through life. A physiologist studies how the nerves, muscles and sense organs are stimulated and coordinated to produce behavior. A psychologist or ethologist is interested in how the whole animal works and the factors that affect it. A behavioral psychologist traditionally studies how an animal learns in a lab while an ethologist describes naturally occurring behaviors in the wild. All of these areas of animal behavior combine to give a complete view of how and why animals act the way they do. Today, however, the scientific study of animal behavior is generally lumped under *ethology*.

The ultimate goal of ethologists is to understand patterns of animal behavior. An ethogram is a complete list of behaviors for an animal. This includes actions alone and with other animals, postures, color changes and vocalizations. Ethologists base their work on repeated observations and measurements.

Like other sciences, the study of animal behavior answers questions using the scientific method. This is a series of steps that build on each other to arrive at conclusions:

1. make a hypothesis (an educated guess)
2. test the hypothesis
3. form a theory
4. prove the theory
5. state a law

Not all studies end in a law, or even a theory on which all scientists agree. It is important to share information so that everyone can keep up with new information and changing ideas.

When your students design behavior studies they should quantify their work with real data. This information can be shared and reproduced. Students should be encouraged to design their own projects, bearing this in mind. Two concepts you might introduce are *interval* studies and how to work with questions and *variables.*

Interval studies identify behaviors at specific times, such as every minute or hour. These studies are good for projects that devote a lot of time to basic animal observation. They help build an ethogram. A stopwatch or watch with a second hand and recording sheet are the basic equipment, with perhaps binoculars for animals that you cannot approach. At the end of each designated time segment, the exact behavior is noted. Behaviors that fall between the intervals are not noted. The behavior list generated from this study can be used to quantify actions. To figure out the time devoted to each behavior, total the check marks in each category. Then total all check marks. Use the following formula to determine what percent of the time the animal spends in each category.

Example: You watch a pigeon for 25 minutes and note its action every minute on the minute. You see grooming 6 times during the 25 observations.

Variables are factors that you can change to manipulate what is happening. Studies that use variables study one aspect of behavior, such as aggression, feeding or choices. In an experiment, the "control" is your baseline reading. It is used to compare against experiments with variables. It is only fair to introduce one variable, or change, at a time and then observe its result. For example, if you were studying to see if crayfish are territorial, you could first watch how one animal uses a defined amount of space. This is the control situation. You might guess that the number of hiding spaces or fellow crayfish, available food or area of the tank make a difference. Each one of these new situations is a variable. The results of these changes compared to the control allow you to make conclusions.

Science Worksheet #2

Partners:

Date:

Fish Selected:

Time Start:

Time Finish:

Behaviors	#of Times Seen
SWIMMING alone	
SWIMMING in pairs	
SWIMMING in group (schooling)	
CHASING bigger fish	
CHASING smaller fish	
PICKING ON other fish	
BEING PICKED ON by other fish	
CLEANING another fish	
BEING CLEANED by another fish	
NOT MOVING on bottom	
NOT MOVING in water	
EATING	
ROLLING/SCRAPING along bottom	
NOT SEEN	
Other descriptions:	

CHAPTER NINE

One emerging resources for aquarium hobbyist and educators these days is the Internet. As such I have decided to include some comments and links regarding web-based resources in this edition. First of all I think the Internet can be a great source of information for anyone looking for information on virtually any topic. However, as those of you who use this resource will probably concur often it is difficult to find the exact information you are looking for, and sometimes the quality of information is questionable. There are quite a few good web pages that focus on the aquarium hobby on the Internet however there also exist some very poor ones. One thing you must keep in mind when considering any information you find on the Internet is the fact that ANYONE can publish a page on the World Wide Web. This means that you can sometimes find information that is either mistakenly incorrect or intentionally malicious. Therefore, I suggest you always be careful and look for credible sources of information. That said there are some really great resources out their for aquariums. On the Internet there are some resources that even specifically cover the topic of aquariums in the classroom. For instance Tetra, maker of a wide array of aquarium products, has a section called Aquademics (http://www.tetra-fish.com/aquademics/) on their website that has a list of educational activities designed for classroom use. Another great way to find a large number of aquarium related links are by using web rings. Web rings are groups of related sites tied together by a common navigational panel. Try visiting the Webrings page (http://www.webring.com/ringworld/misc/pets.html) and type in the word aquarium or fish. Below I will list a few other sites that might be of interest to the aquarium hobbyist.

Informational Sites:

F.I.N.S (Fish information Service)
http://www.actwin.com/fish/index.cgi
This is an archive of information about aquariums. It covers both freshwater and marine, tropical and temperate.

Aquarium Fish Magazine
http://www.aquariumfrontiers.com/fish/default.asp
Link to the site for a popular aquarium magazine.

Aquarium Fish Magazine
http://www.aquariumfrontiers.com/fish/aqfm/default.asp
Link to the site for a popular aquarium magazine.

Aquarium Fish Magazine
http://www.breeders-registry.gen.ca.us/
A link about breeding and propogating marine fish and invertebrates.

Tropical Fish Atlas
http://www.geocities.com/Heartland/Meadows/8945/index.html
A nice general aquarium resource.

Reefs.org
http://www.reefs.org/
A reef aquarium resource.

Product Sites:

That Fish Place
http://www.thatpetplace.com/
Discounted aquarium supplies.

Pet Warehouse
http://www.petwhse.com/
Another aquarium supplies.

Champion Lighting
http://www.championlighting.com/
A good source for mail order marine aquarium supplies.

Aquarium Center (Randallstown, MD)
http://aquariumcenter.com/
A nice local livestock and supply company.

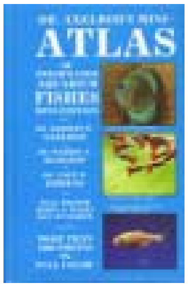
Pet Blitz (Ocean City, MD)
http://www.angelfire.com/md/petblitz/welcome.html
When at the beach, visit them.

Roozen's
http://www.roozens.com/
Another local shop, that specializes in marine fish and inverts.

CHAPTER TEN

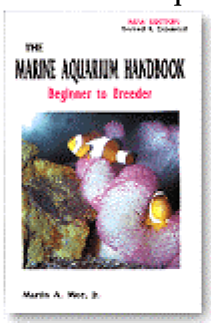
Suggested Reading:

Freshwater Aquariums



Axelrod, Herbert., (1996) Atlas of Freshwater Aquarium Fishes

Saltwater Aquariums



Moe, Martin., (1998) The Martin Moe Handbook: From Beginner to Breeder,

Reef Aquariums

Delbeek, C., Sprung, J., (1994) The Reef Aquarium, Ricordia Publishing, Coconut Grove, FL